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To Tracy Woodson
Patent Office
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Re your fax To SML

The fax was for Application No. 09/749988. Formal Amendment

The attached pages are page 37,38 and 40 from the Marked Up specification,which you told me were missing.

Yours truly,

Stephen M. Lord

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kW on average. Power to the hydrogen preheater was 5kW initially decreasing to 3 kW as the hydrogen flow to the preheater was reduced by the increase in flow to the bead cooler, 12. Power to the upper wall heaters varied between 3 and 5 kW depending on the amount of cold undersize granules recycled to the reactor. Total power was 12 to 16 kW for a production rate of 13.5 kg/hr, which is about 1kW/kg. Energy requirements are based on a silane vapor feed.

Scale up of these reactors is much more feasible than in previous technology as is illustrated in Figs 1b & c. The diameter of the main reactor is increased from 10 cm to 50 cm which means increasing the cross-sectional area, throughput and heat input requirements by 25 times. The bead heaters need to deliver 25 times more heat and so must increase in surface area and /or in the temperature of the heater.

In the example, shown in figs 1b &c, a center tube, 20, is increased to 10 cm thus doubling the surface area per foot and an additional 8 tubes,24a-g, each 10 cm in diameter are provided in an outer ring ~~(21a through g)~~ This provides 17 times the surface area per foot and the length of the heaters is increased by 50% thus providing 25 times the surface area. Alternatively the length could be increased by 30% and the temperature difference from the heater to the tube increased by 20% from 50 deg C to 60 deg C to provide the additional heat transfer. Thus there are three parameters that may be adjusted to provide the extra heat transfer, the surface area/ft, the length and the temperature difference. In practice a higher temperature difference shifts the frequency of the radiant heat towards the visible and more is transmitted through the quartz, which is an additional benefit. It is also necessary to increase the number of silicon

containing gas inlets and here it is shown that 8 inlets, 8a-g, are provided for the 25-fold increase in flow. Increasing the inlet diameter and/or the pressure drop across them can do this. The fraction of heat input lost to parasitic heat loss from cooling the nozzles decreases by a factor of three.

In this design the heater elements are arranged in two rings an inner ring 22, and an outer ring 23. This provides an efficient furnace. The outer ring is insulated, 23, on the outside, top and bottom. The top of the inner ring heater may or may not be insulated depending on the distance of the heater from the silane inlet nozzle. In general for larger reactors it is not insulated, as shown, to provide more heat and in smaller reactors it is insulated to reduce the wall deposits. Gas flow to each tube is pulsed and this may be done in any convenient fashion providing that the flow is evenly distributed. Since it is convenient for bead removal to be done via the center tube, this tube will normally have its own flow controller.

An example of silicon deposition using a dual stage reactor that is designed for silane and is similar to the design shown in Figure 2 but with six silane inlets, each with an associated pulsing device, inlet cooler, water inlet and water outlet, instead of the four inlets shown in Fig. 2 is as follows.

A quartz vessel consist ing of a lower bead and gas heater zone of 90 cm length and 5 cm in diameter and a lower insulated reaction zone of 150 cm length and 10 cm diameter and an upper bead and gas heater zone of 90 cm length and 10 cm in diameter and a upper insulated reaction zone of 570 cm length and 13 cm diameter was loaded with a 480 cm bed of 850 micron average diameter silicon beads. The reactor, effluent piping and cyclone are well insulated. The hydrogen preheater and the bead /gas heater were set at 900 °C, the SCG heater vapor

hydrogen/bead heater was 3 kW on average. Power to the hydrogen preheater was 5kW initially decreasing to 1 kW as the hydrogen flow to the preheater was reduced by the increase in flow to the bead cooler. Power to the silane heater was 6 kW on average. Power to the lower wall heaters was 3kW on average. Power to the upper wall heaters varied between 5 and 7 kW depending on the amount of cold undersize granules recycled to the reactor. Total power was 22 to 24 kW for a production rate of 27 kg/hr, which is about 0.8-0.9 kW/kg. While not shown it is also possible to provide a recycle bead heater on stream 16 which will reduce the load on the upper wall heater and thus tend to reduce wall deposits in that area.

An example of silicon deposition using dual stages and designed for trichlorosilane using a design similar to that shown in Figure 3a but with 3 Trichlorosilane inlets, and 3 hydrogen inlets,and associated pulsing devices and inlet coolers, water inlets, and water outlets, instead of the 2 trichlorosilane and 2 hydrogen inlets shown in Fig. 3a is as follows:

The same quartz vessel and silicon granule bed as used in Example 2 is used. A hydrogen superheater is supplied capable of heating hydrogen to 1300 °C using Kanthal heating elements. The important function of increasing the yield of silicon from trichlorosilane is shown using gas heating in conjunction with wall heating. In the trichlorosilane decomposition there are two main reactions; thermal decomposition to silicon and silicon tetrachloride and hydrogen reduction to silicon and hydrogen chloride. The second reaction produces more silicon per mole of trichlorosilane but requires dilution with hydrogen and higher temperatures. Since the reactions are equilibrium reactions the products of the reaction of the reaction inhibit the reaction so direct recycle of effluent is not